Section 17
KSC Biotube-01 Presentation
April Boody

STS-107 Fundamental Biology Project
NASA Ames Research Center

Biotube-01 Phase A/B Agenda

- Science Requirements
- Hardware Requirements
- Mission Requirements
- Payload Configuration
- Resource Summary
- Mission Testing Plan
- Integrated Experiment Schedule
- Procedures
- Crew Training Readiness
- Budget
- Biotube Precursor

Biotube-01 Team

- Payload Mission Manager
  - NN-L1-LS: David Cox
- Project Scientist
  - JJ-G: William Knott
- Project Engineer
  - BIO-8: April Boody
- Hardware Engineer
  - BIO-3: Ken Anderson
- Project Science Coordinator
  - DYN-3: Howard Levine
- Principal Investigator
  - University of Louisiana: Karl Hasenstein

Biotube-01 Payload Overview

- **Investigator: Dr. Karl Hasenstein, University of Louisiana at Lafayette**
- **Science and Hardware Management: KSC**
- **First flight of Biotube-01 hardware**
- **Experiment Objective: To use magnetic fields to influence the growth of plant roots in microgravity**
- **Hardware Objective: To imbibe seeds, take video images of roots, and fix seedlings. Temperature data will be recorded, but not controlled. All Biotube-01 hardware functions are computer controlled**
- **Authorization to proceed to Phase B granted in September 1996**

Biotube-01 Science Requirements - Description/Objectives

- **To determine if amyloplasts are the organelle in plant cells that perceive gravity**
- **To determine whether the intracellular position of amyloplasts in the absence of gravity affect spatial growth orientation**
- **To determine if gravity exerts a controlling effect on the deposition of wall material in plant cells**

Biotube-01 Science Requirements -

Hypothesis:

The hypotheses to be tested include the determination of whether or not:

- **The positioning of amyloplasts in statocytes of the columella region of the root cap determines the future growth direction of the root**
- **The microtubular and F-actin cytoskeleton is affected by microgravity**

Biotube-01 Science Requirements

Experiment Overview

- **The gravisensing system, specifically the role of amyloplasts, will be studied by applying directional stimuli using high gradient magnetic fields (HGMF), which enable the displacement of amyloplasts**
- **The investigator's research has shown that *in vitro* and *in vivo* amyloplasts move along the gradient of the magnetic field**
- **Aside from studying the application of HGMF in directional growth control, the experiments will test whether the force exerted by amyloplasts of their position inside sensory cells controls the direction of growth**

Biotube-01 Science Requirements - Status

KSC Testing

- Science Verification Test #1 ran for three days in November 1998 - prototype hardware used
  - Hardware/science biocompatibility issue prevented seed germination
- Science Verification Test #2 ran for 11 days in December 1999 - prototype hardware used
  - No biocompatibility issues
  - PI states hardware will support proposed science

PI Ground Testing

- Extensive testing using Magnetic Field Chamber hardware to determine required magnetic field strength
- Clinostat studies

Biotube-01 Hardware Requirements -
Hardware Performance Requirements Summary

The Biotube-01 payload will use the newly developed Experiment Unique Equipment Magnetic Field Apparatus hardware system for spaceflight experimentation

The Hardware will perform the following operations:

- **Initiate a pre-programmed imbibition of seeds on-orbit by the precise delivery of a specified quantity of water**
- **Expose the resulting seedling roots to high gradient magnetic fields**
- **Record digital images of root growth**
- **Deliver a fixative to the seedlings to terminate the experiment prior to re-entry**

Hardware Requirements - Hardware List

Generic External Shell

- Structural interface, replaces single middeck locker

Generic Containment Unit

- Provides three redundant levels of containment for contents

Magnetic Field Chamber

- Each contains eight seed cassettes/64 seeds per MFC

Micro-Effusion Delivery Unit for Space Applications

- Delivers water to seed cassettes in MFCs

Fixative Delivery System

- Delivers fixative sequentially to each MFC

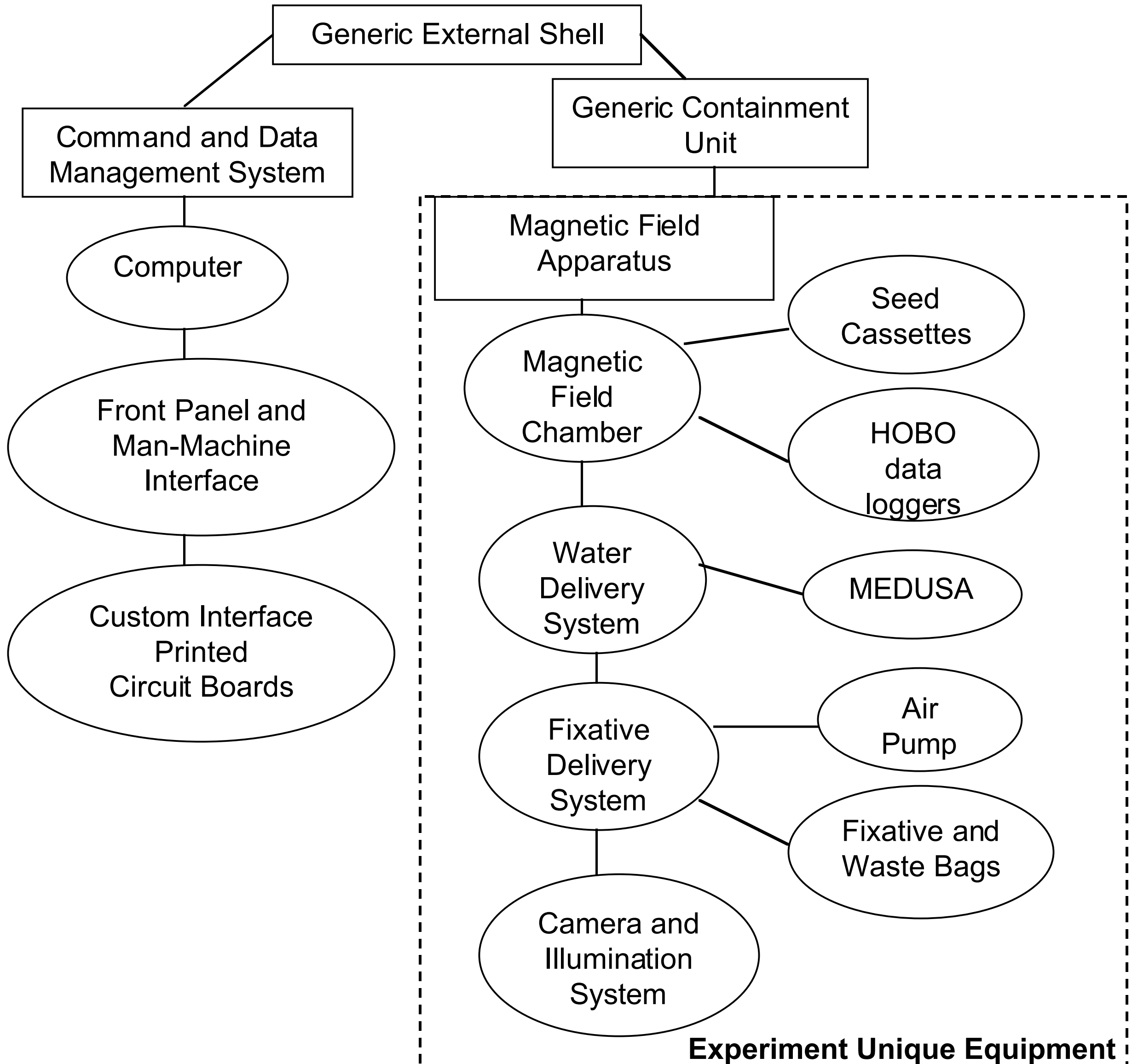
Digital Imagery System

- Four digital cameras to record images of roots as they pass through the magnetic field

Command and Data Management System

- Provides automated control of payload operations

Biotube - 01 Hardware Summary

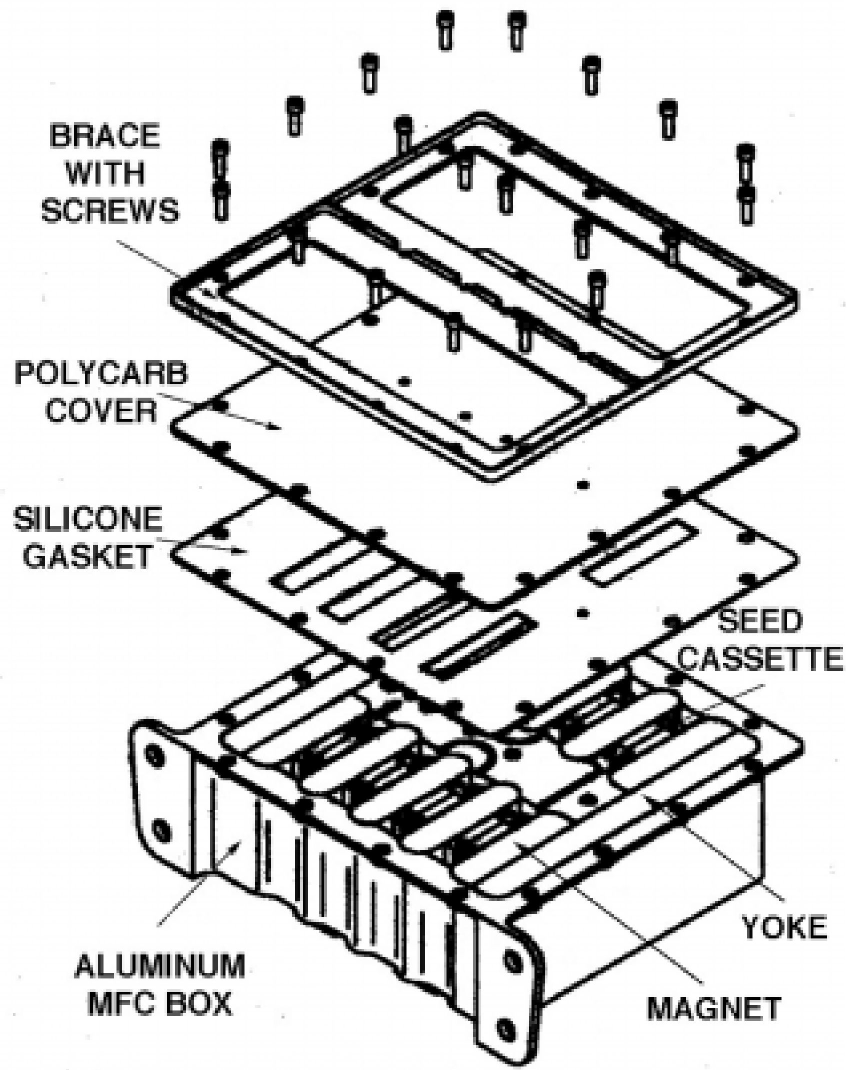


Magnetic Field Chamber

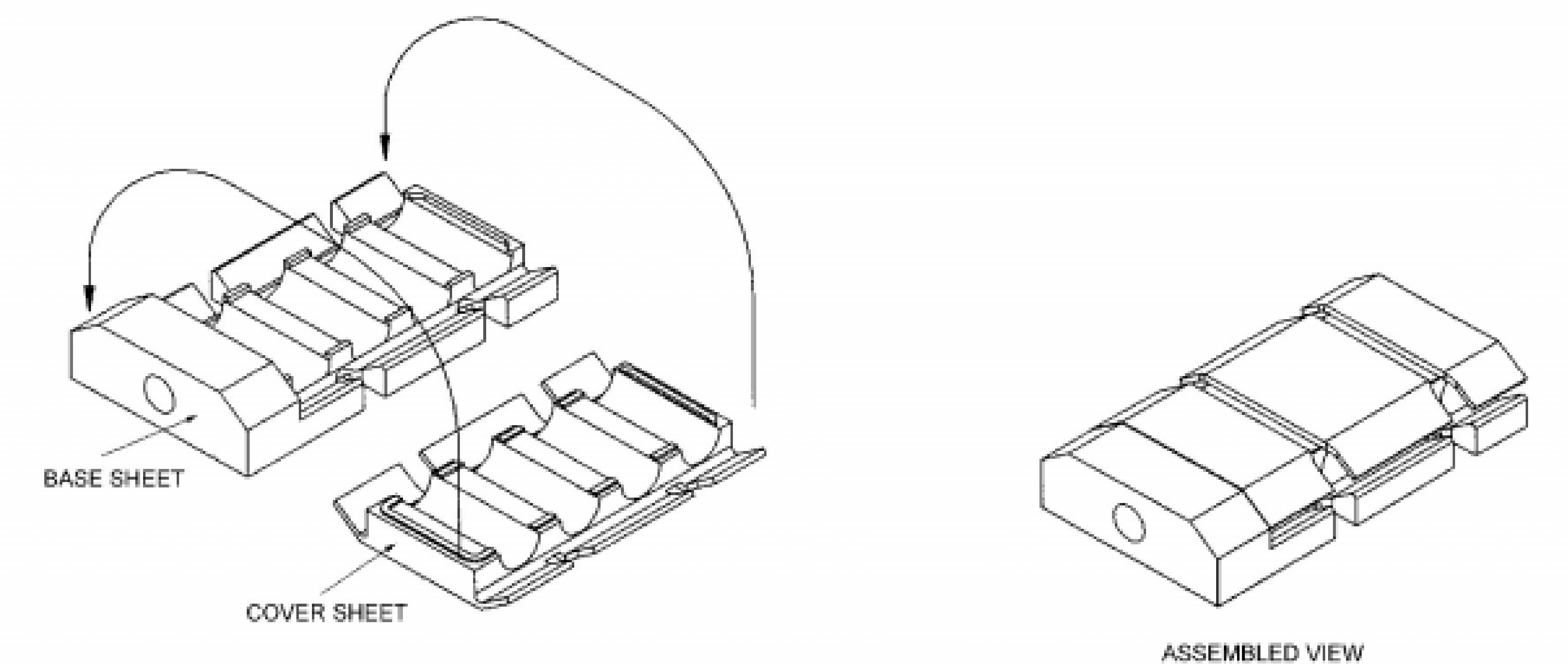
- Three MFCs total, each contains 10 neodynium iron boron permanent magnets. Two steel yokes on each MFC strongly attenuate stray magnetic fields from leaking outside MFC

- Each MFC contains eight polycarbonate seed cassettes

Magnetic Field Chamber



Seed Cassette



Micro-Effusion Delivery Unit for Space Applications

- **MEDUSA has a total of twenty-four Teflon tubes attached to the top. Individual Teflon tubes run to each seed cassette located in each MFC**

- **A stepper motor delivers 50 µL of water at a time to the seed cassettes, 600 µL total water volume per seed cassette**

Micro-Effusion Delivery Unit for Space Applications

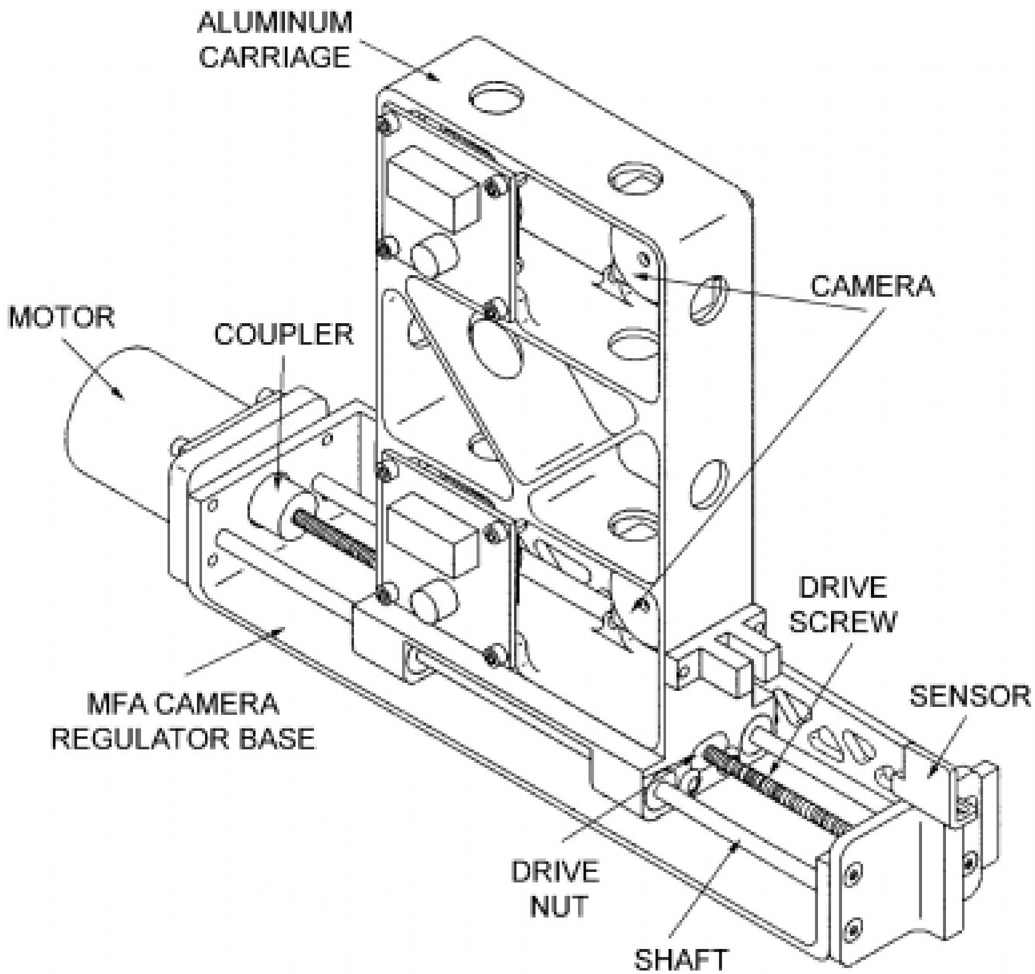
Fixative Delivery System

- Three fixative bags (4% formaldehyde, 96% PHEMD buffer) contained in Storage Container
- An air pump pressurizes the Storage Container, causing fixative to flow from bags and to MFCs
- MFCs fill one at a time by fixative flowing serially around all seed cassettes

Camera and Illumination System

- Composed of four CCCD cameras and four infrared Light Emitting Diodes
- The camera carriage travels along a drive screw
- Lights turn on, cameras take images, lights turn off, camera carriage travels to next position
- Images are recorded for approximately 38 hours

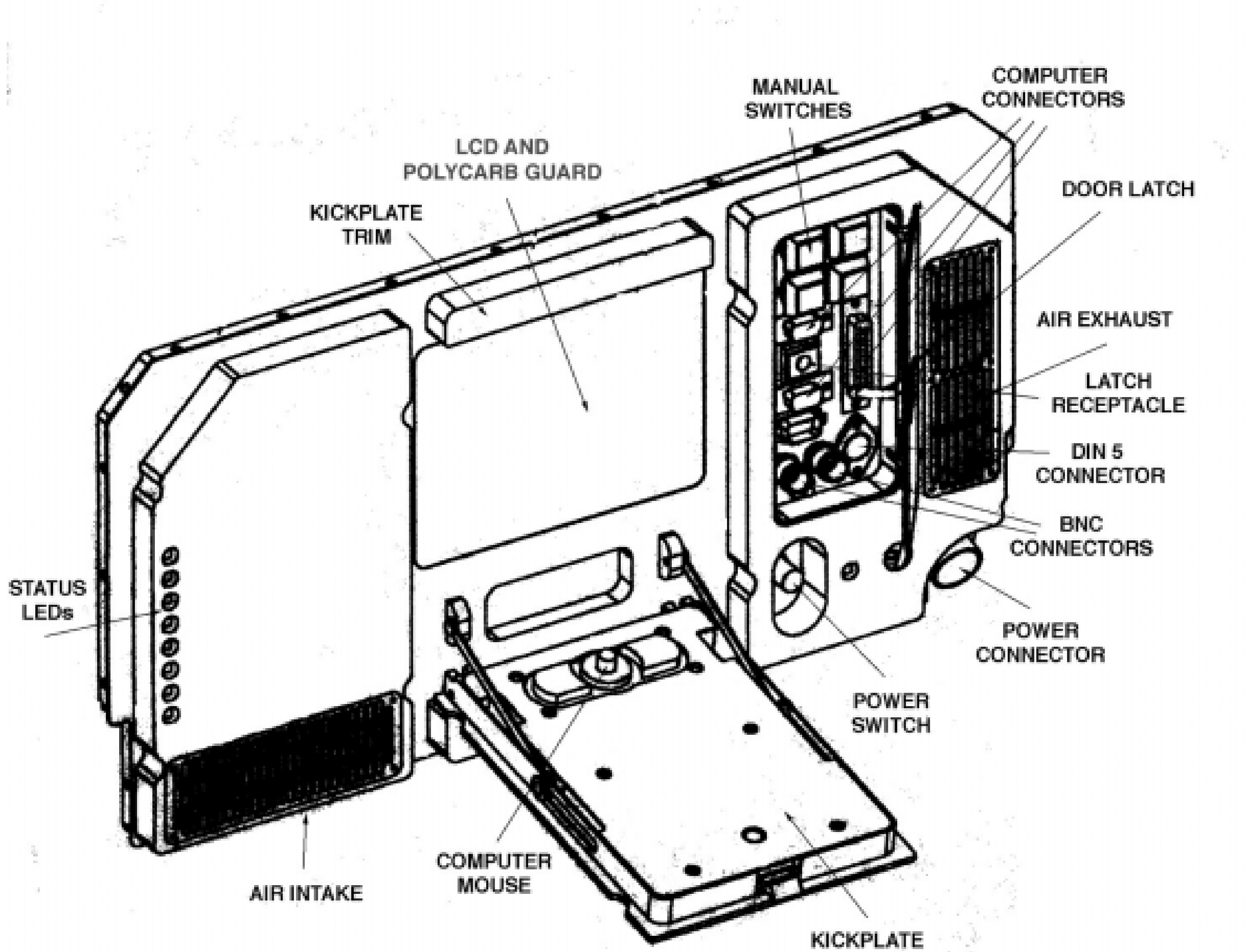
Camera and Illumination System



Hardware Interfaces

- The Biotube-01 payload requires a 28 VDC power connector. Power is only required during the 48 hour Biotube-01 operations
- Crew interface is via the front panel man-machine interface
- Crew turns power on to initiate experiment, performs status checks, and turns experiment off following fixation. Once initiated, all Biotube-01 operations are controlled by the Command and Data Management System (CDMS). Manual override switches are available for crew use in the event of a CDMS failure

Hardware Interfaces



Hardware Development Status

- PDR complete - February 1998
- CDR complete - March 2000
- Phase 0/1 Flight Safety Review complete - January 2000
- ERD baseline - April 2000
- Flight hardware fabrication complete - June 2000
- End-to-End testing/PI clinostat test - August 2000

Mission Requirements

- Installation at L-36 to L-32 hours
- Scrub Turnaround: 96 hours
- Runway removal prior to Orbiter tow at R+3-5
- Power required: On-orbit only
- Total payload operating time: maximum 48 hours
- Experiment can be initiated at any time during the mission, prefer as close to R-2 days as possible to minimize fixative degradation
- Support required at both primary and secondary landing sites beginning 10 hours after experiment initiation
- Ground control: Will utilize KSC Orbiter Environmental Simulator to mimic the middeck/SPACEHAB cabin environment with a 96 hour delay

Payload Configuration

Facility Hardware

- Biotube-01 hardware

Stowage/EUE

- None

Resource Summary

Power Profile

- 28 VDC power required on-orbit during Biotube-01 operations only; no ascent or descent power
- Maximum continuous power: 60 W
- Peak power: 88 W (during camera lighting activities)

Thermal

- Requires a location not adjacent to a heat producing payload/equipment

Mass Properties

- Total single locker weight less than 70 pounds

Crew Time

- Minimal Crew time for initiation, status checks, and termination

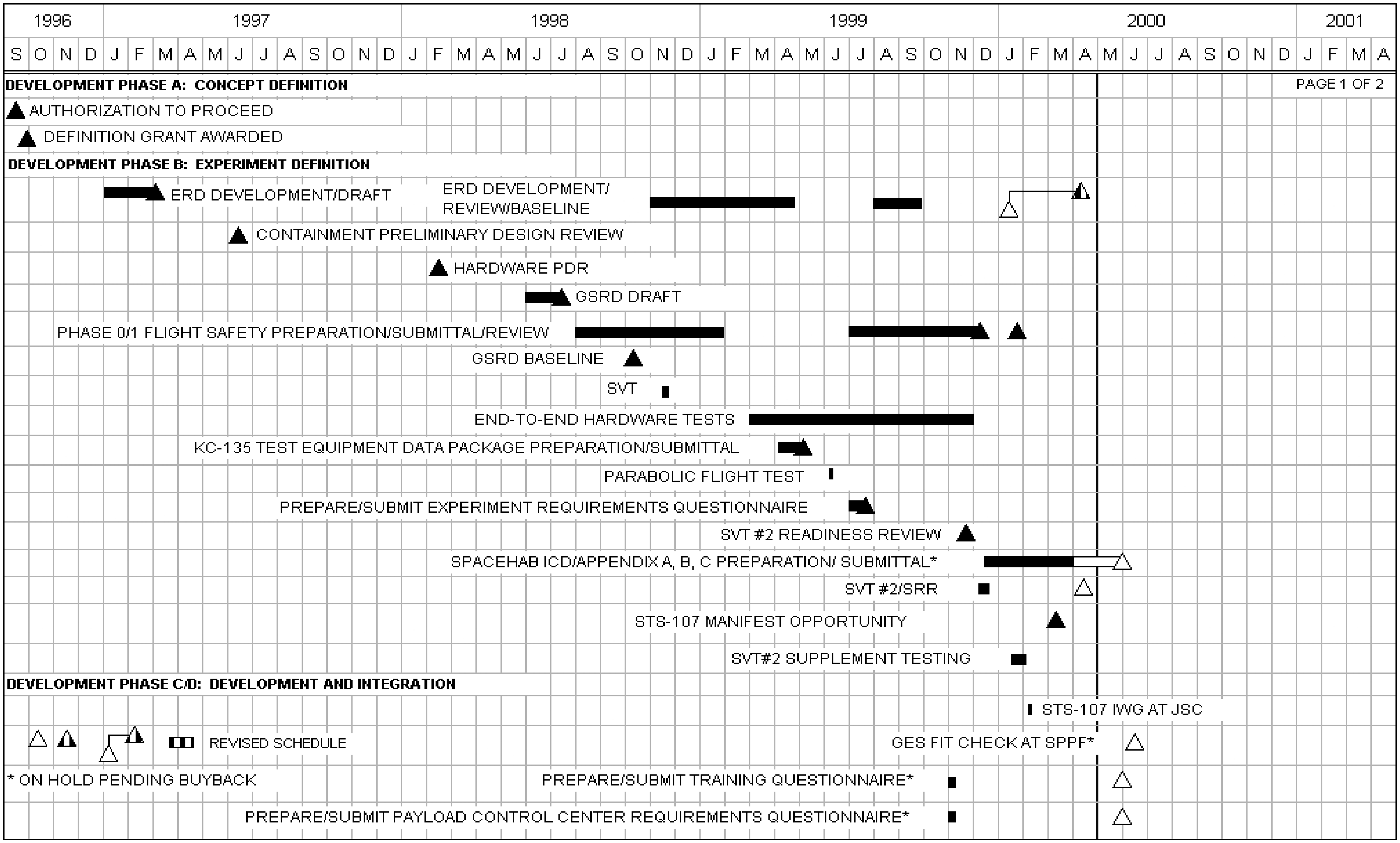
Mission Testing Plan

- **SVT complete - January 2000**
- **PVT target - Late October/early November 2000**

Biotube-01 Schedule

Mar 31, 2000

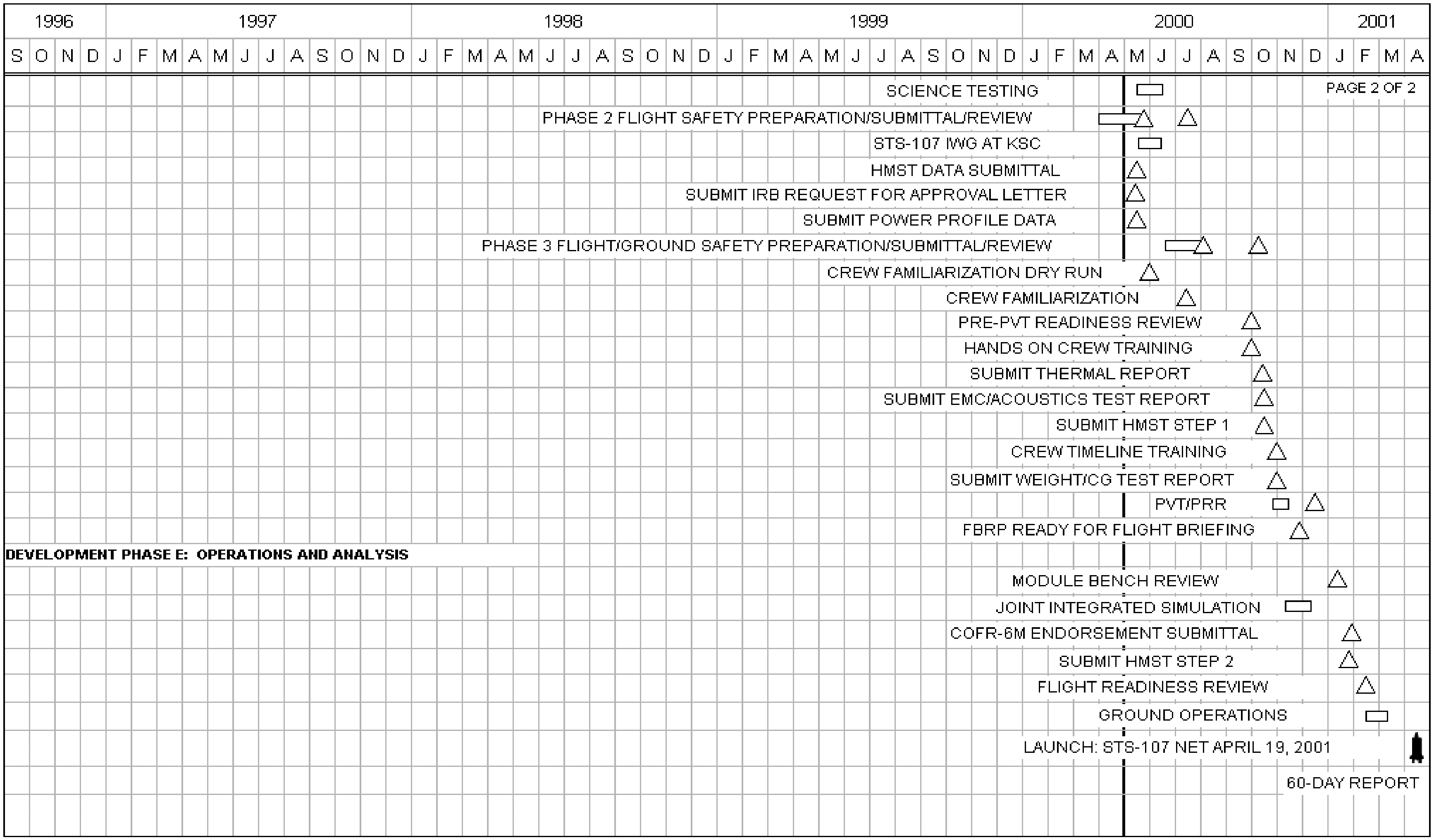
FLIGHT EXPERIMENTS PROJECT MANAGEMENT
KENNEDY SPACE CENTER
BIOTUBE/MAGNETIC FIELD APPARATUS (MFA-1)



Biotube-01 Schedule (Cont'd)

Mar 31, 2000

FLIGHT EXPERIMENTS PROJECT MANAGEMENT
KENNEDY SPACE CENTER
BIOTUBE/MAGNETIC FIELD APPARATUS (MFA-1)



Biotube - 01 Procedures

- Initiate experiment by turning power on
- Monitor experiment progress/status checks
- Terminate experiment by turning power off
- In the event of a Command and Data Management System failure, the crew will manually initiate imbibition and fixation

Biotube - 01 Crew Training Readiness

- **Crew training will be performed using flight hardware**
- **Earliest expected crew training readiness: July 2000**

Biotube - 01 Budget

PI budget complete

- Approved by Program Office and Technical Monitor
- Grant Agreement funded
- Period of performance: FY00

Project budget complete

- Submitted in POP cycle

Biotube Precursor on STS-101
Space Shuttle Program Status

- Flight and Ground Safety Packages have been reviewed and approved. All Flight Safety Package Verification Tracking Log (VTL) items are closed. A Ground Safety VTL was not required
- Crew familiarization and Bench Review are complete
- Certificate of Flight Readiness (COFR) submitted in February 2000
- Turnover of Biotube Precursor tray scheduled for Monday, May 15, 2000
- STS-101 is schedule to launch at 6:33 a.m. EDT

BRIC-Sack Phase A/B Agenda BRIC-Sack Phase A/B Agenda

- BRIC-Sack Team
- Science Requirements
- Hardware Requirements
- Mission Requirements
- Payload Configuration
- Resource Summary
- Mission Testing Plan
- Integrated Experiment Schedule
- Procedures
- Crew Training Readiness
- Budget

BRIC-Sack Team

- Payload Mission Manager
  NN-L1-LS: Bridgit Higginbotham
- Project Scientist
  JJ-G: William Knott
- Project Engineer
  BIO-8: Roberteen McCray
- Hardware Engineers
  BIO-3: Bill Wells/Charlie McFarland
- Project Science Coordinator
  DYN-3: Howard Levine
- Principal Investigators
  Ohio State University: Fred Sack
  Ames Research Center: Volker Kern

BRIC-Sack Payload Overview

- **Investigators: Dr. Fred Sack, Ohio State University; Dr. Volker Kern, Ames Research Center**
- **Science and Hardware Management: KSC**
- **Series reflight of the BRIC hardware**
- **Experiment Objective: To identify factors that contribute to the non-random orientation and distribution of amyloplasts in the tip of moss *Ceratodon* cells.**
- **Hardware Objective: To provide a sterile environment for the moss to grow until the delivery of the inhibitor and fixative is complete. Temperature data will be recorded, but not controlled.**
- **Authorization to proceed to Phase B granted in March 1999.**

BRIC-Sack Science Requirements - Description/Objectives

- To confirm that spiral growth of moss cells is a predictable response to microgravity.
- To determine whether the cytoskeleton plays a role in maintaining and generating an apical (non-random) plastid distribution in microgravity.
- To determine the age at which clockwise growth starts to be expressed by comparing dark treatments to pre-orienting red light treatments.

BRIC-Sack Science Requirements - Hypothesis

The hypotheses to be tested include the determination of whether or not:

- Older moss cultures produce spiral growth in shorter periods of exposure to microgravity than younger moss cultures.
- Both microtubules and microfilaments are required for maintaining a non-random distribution of amyloplasts in microgravity.
- In microgravity gravitropism and phototropism in low intensity light are separable from each other.

BRIC-Sack Science Requirements - Experiment Overview

- **Cultures will be grown in the dark to determine the threshold exposure to microgravity for the expression of spiral growth of the moss.**
- **Cultures will be grown under low red light intensities to examine the interaction between gravitropism and phototropism.**
- **The analysis of whether non-random amyloplast distribution requires cytoskeletal integrity, by applying inhibitors followed by chemical fixation *in situ*.**

BRIC-Sack Science Requirements - Status

KSC Testing

- Science Verification Test - April 19 - May 9, 2000
  - In progress

PI Ground Testing

- Extensive testing using different inhibitors, chemical fixative concentrations and light intensities are continuing.

BRIC-Sack Hardware Requirements - Hardware Performance Requirements Summary

The BRIC-Sack payload will use the existing BRIC-LED hardware including existing Petri Dish Fixation Units and Experiment Unique Equipment Petri Dish Fixation Units for space flight experimentation.

The Hardware will perform the following operations:

- **Provide a sterile environment for moss growth.**
- **Provide a two-stage delivery system for the inhibitors and fixative prior to re-entry.**
- **Provide low level directional light.**
- **Provide three redundant levels of containment for hazardous materials.**

Hardware Requirements - Hardware List

Custom Stowage Tray
- One half middeck locker aluminum tray. Provides forced airflow and mounting for BRIC-LEDs

BRIC-LED Canisters (8)
- Each canister contains six positions for Petri Dish Fixation Units and data logger

Petri Dish Fixation Units (47)
- Houses the petri dish in which the moss cultures are planted

Inhibitor/Fixative Delivery System
- Delivers inhibitor and/or fixative to each petri dish

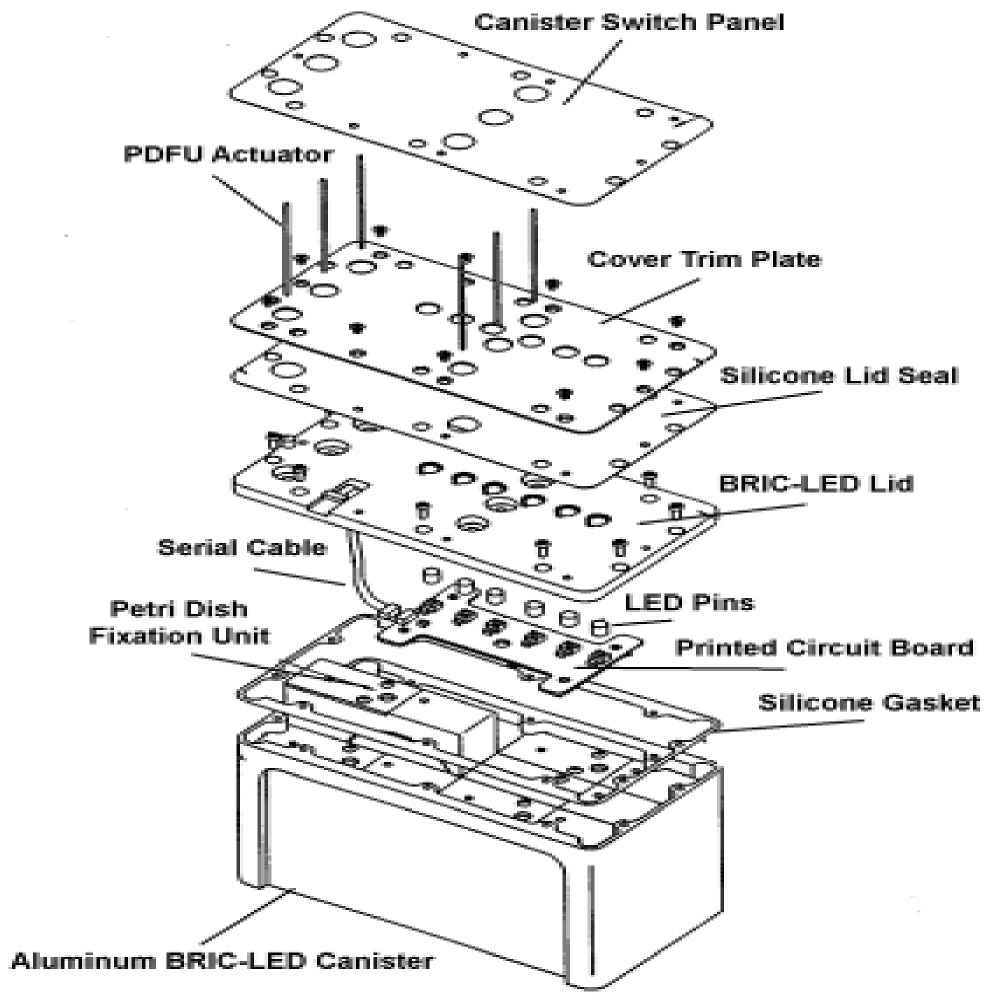
Actuator Tool and Rods
- Initiates the delivery of the inhibitor and/or fixative

HOBO
- Temperature Data Logger for passive recording

BRIC - LED

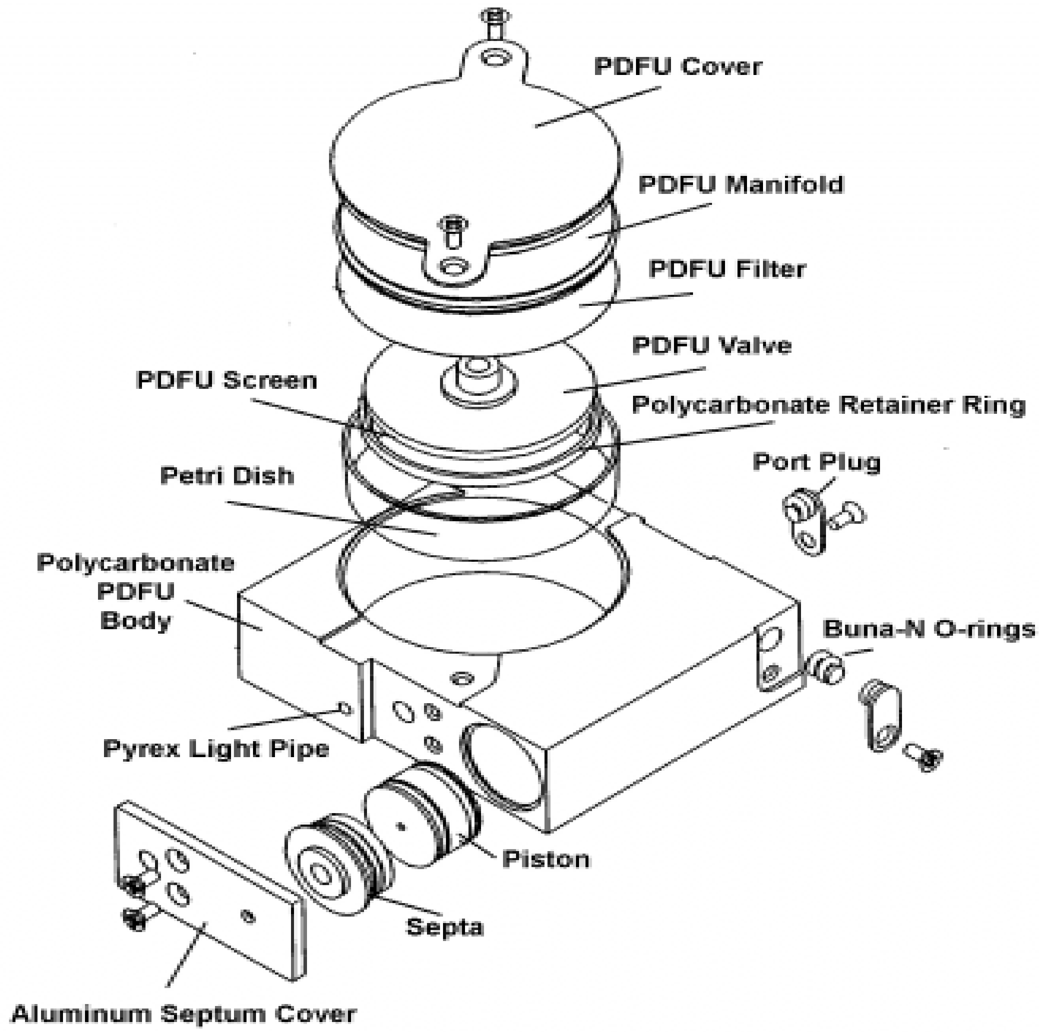
- **Eight BRIC-LEDs contain six PDFUs each.**
- **Thirty PDFUs will be the originally designed version used during CUE.**
- **Seventeen PDFUs will be the modified version which has a two stage inhibitor/fixative delivery system.**
- **A HOBO Temperature Data Logger will be located in one PDFU slot.**

BRIC - LED



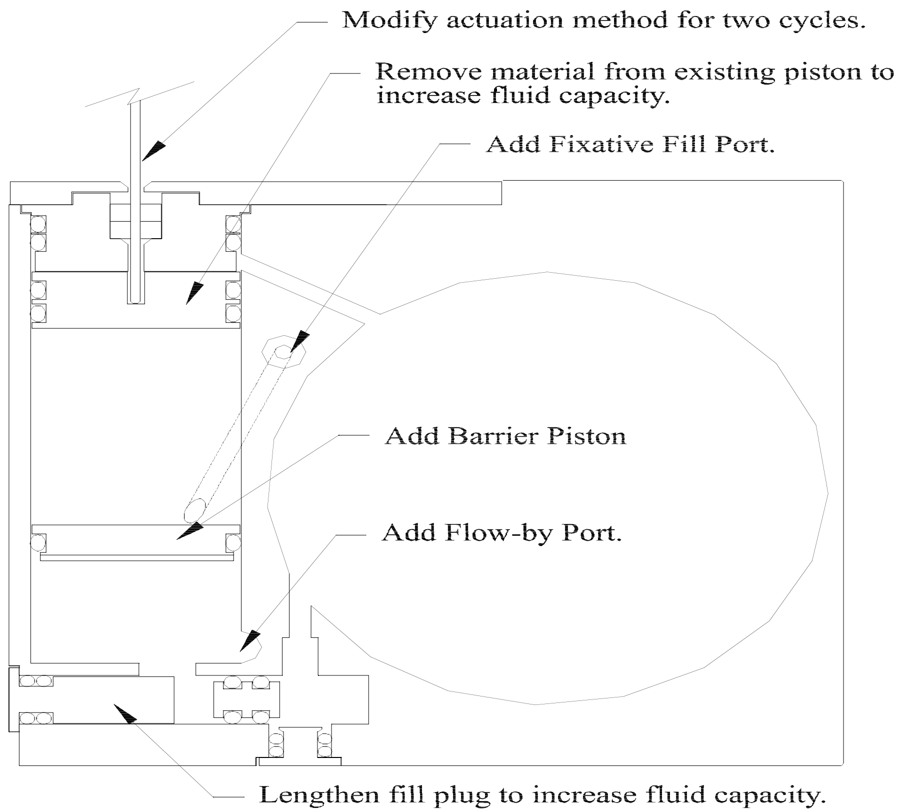
Canister Switch Panel
PDFU Actuator
Cover Trim Plate
Silicone Lid Seal
BRIC-LED Lid
Serial Cable
LED Pins
Petri Dish
Fixation Unit
Printed Circuit Board
Silicone Gasket
Aluminum BRIC-LED Canister

PDFU
(Petri Dish Fixation Unit)



Modified PDFU Inhibitor/Fixative Delivery System

SACK modifications to existing PDFU hardware



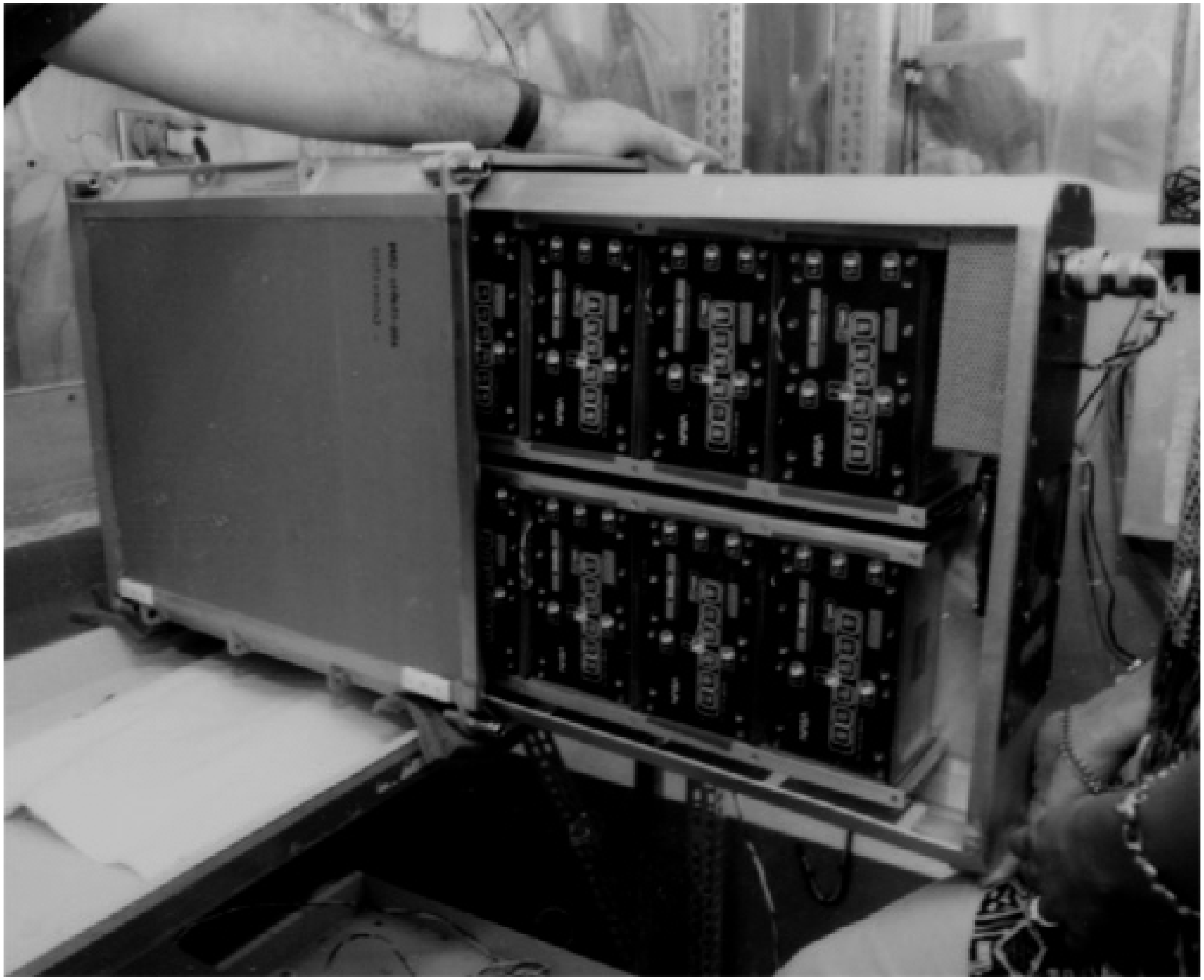
No changes adversely affect current operating parameters

SACK Concept
Sht 1 of 3
02/25/1999

Hardware Interfaces

- **The BRIC-LED payload requires a 28 VDC power source.**
- **Crew interface is via the front panel man-machine interface.**
- **Crew turns the LEDs on and off on selected canisters, and performs the inhibitor and/or fixative delivery in each PDFU.**

Hardware Interfaces



Hardware Status

- Flight Hardware Fabrication (modified PDFUs) - July 2000
- Phase 3 Series/Reflown Flight Safety Review - September 2000

Mission Requirements

- Installation at L-19 to L-17 hours
- Scrub Turnaround: 24 hours
- Runway removal prior to Orbiter tow at R+ 3 - 5
- Power required: Assent and FD 8 - 9
- Total payload operating time: L-7 d to L+1, R-2 d
- Experiment will be initiated seven days prior to launch
- EEOM support required at both primary and secondary landing sites beginning after launch
- Ground control: Will utilize KSC Orbiter Environmental Simulator to mimic the middeck cabin environment with a 24 hour delay

Payload Configuration

Facility Hardware

- BRIC-LED hardware
- Occupies a single half-locker tray equivalent

Stowage/EUE

- None

Resource Summary

Power Profile

- 28 VDC power required on-orbit during Flight day 1 and Flight days 8 and 9; no descent power
- Maximum continuous power: 30 W
- Peak power: 40 W

Thermal

- Requires a location not adjacent to a heat producing payload/equipment

Mass Properties

- 45 pounds

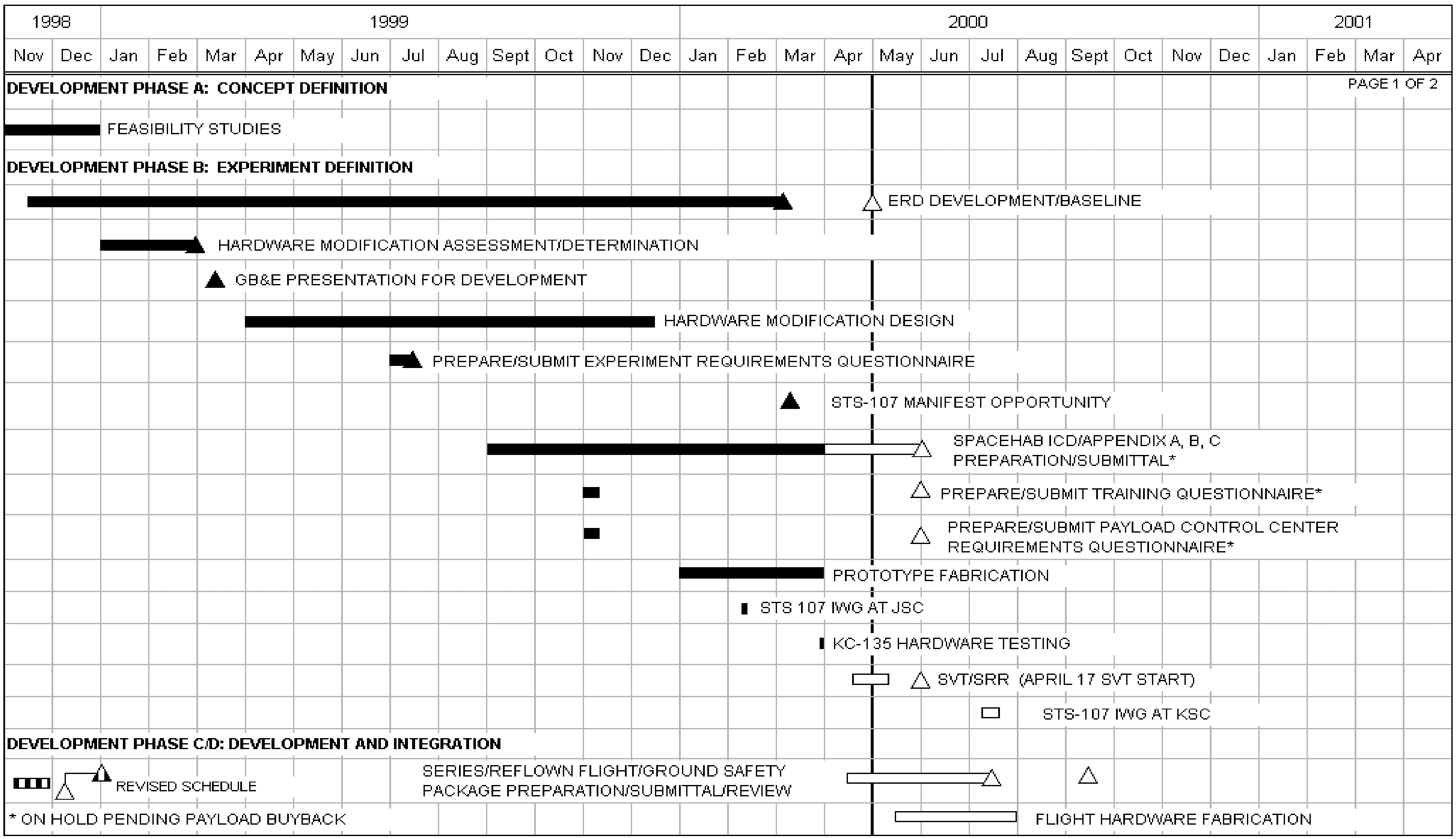
Mission Testing Plan

- SVT complete - May 2000
- PVT target - Late September/early October 2000

BRIC-Sack Schedule

Mar 31, 2000

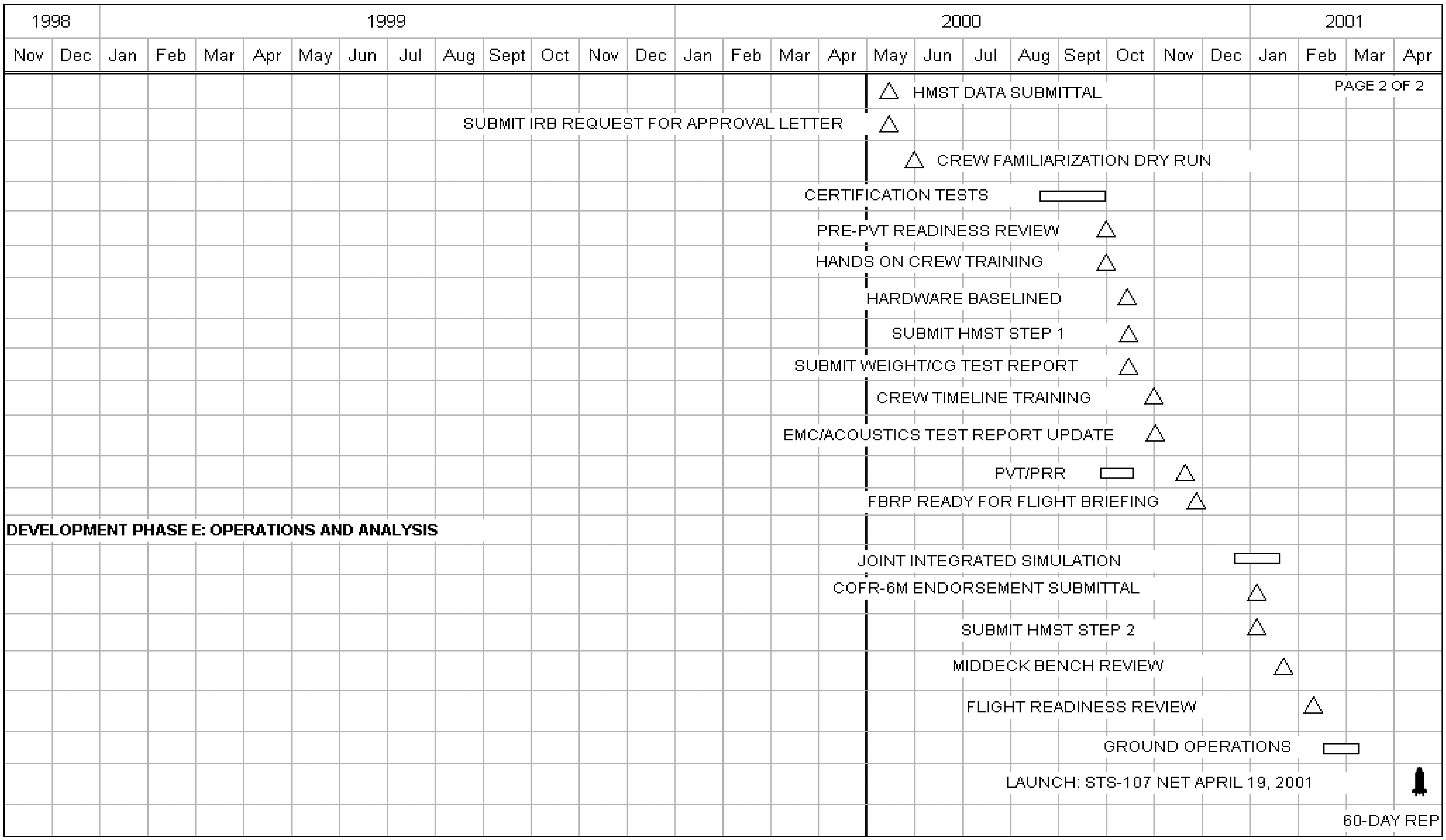
FLIGHT EXPERIMENTS PROJECT MANAGEMENT
KENNEDY SPACE CENTER
BRIC-SACK



BRIC-Sack Schedule (Cont'd)

FLIGHT EXPERIMENTS PROJECT MANAGEMENT
KENNEDY SPACE CENTER
BRIC-SACK

Mar 31, 2000



BRIC-Sack Procedures

- Initiate experiment by turning the lights off in designated BRIC-LED canisters.
- Monitor experiment progress/status checks.
- Turn the lights on in designated BRIC-LED canisters.
- Terminate experiment by delivering all inhibitors and fixatives.

BRIC-Sack Crew Training Readiness

- **Crew training will be performed using flight hardware.**
- **Earliest expected crew training readiness: July 2000**

BRIC-Sack Budget

PI budget complete

- Approved by Program Office and Technical Monitor
- Grant Agreement funded
- Period of performance: FY00

Project budget complete

- Submitted in POP cycle